

Nutrient element contents of cutting seedlings of hybrid species (*Liriodendron chinense* x *tulipifera*)

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Abstract: The cutting seedlings of *Liriodendron chinense* x *tulipifera* were treated with the different concentrations of auxin (treatment₁: IBA of 50 g·kg⁻¹ + NAA of 300 g·kg⁻¹; treatment₂: IBA of 100 g·kg⁻¹ + NAA of 300 g·kg⁻¹). The biomass and the nutrient element contents for different organs (root, stem, leaf) of cutting seedling of *Liriodendron chinense* x *tulipifera* were measured by the dry method, Kjeldahl method and Atomic Absorption Spectroscopy method. The result showed that the biomass of root, stem, and leaf of the cutting seedling treated with auxin was all remarkably increased. The contents of element C in root, stem and leaf had no significant difference between the control and auxin treatments, while the contents of N, P, K and Ca in stem were much lower than that in leaf and root. Variance analysis showed that for the same organ with different concentration treatment of auxin, the four nutrient elements (N, P, K, and Ca) had no significant difference in contents, while there existed significant or very significant difference in contents of the four nutrient elements in different organs with the same concentration auxin treatment. The N, P, K and Ca contents were very low in cutting seedlings; as a result, additional fertilizer should be applied to the seedlings when they were planted in the field.

Keywords: Hybrid species (*Liriodendron chinense* x *tulipifera*); Cutting Seedlings; Nutrient contents

CLC number: Q945.12

Document code: A

Article ID: 1007-662X(2003)04-0307-04

Introduction

Liriodendron chinense (Hemsl.) is widely planted in the subtropical region of China. The fecundity and survival rate of seedling of hybrid species (*Liriodendron chinense* x *tulipifera*) are very low (Fang *et al.* 1994, 1999) due to its flowering-phase discrepancy, self-incompatibility, and inconsistent development between embryo and endosperm (Huang 1998; Huang *et al.* 1998; Zhou *et al.* 1994; Qin *et al.* 1996). Biological and ecological studies on this species are currently focused on propagation, anatomy, genetics, and so on (Zhang *et al.* 2003; Yin *et al.* 1998). However, there were few reviews concerning the distribution of nutrient elements contents during its cutting process. In this paper, the distribution of biomass and contents of nutrient elements in different organs of *Liriodendron chinense* x *tulipifera* seedling were studied in order to provide some theoretic basis for cultivation.

Materials and method

On 22 July, 2000, the soft branches of *Liriodendron chinense* x *tulipifera* were cut down from 1-2 years old trees, and a total of 300 cuttings were collected. The cuttings were soaked for 12 h by three different auxin treatments

(control: water; treatment₁: IBA of 50 g·kg⁻¹ + NAA of 300 g·kg⁻¹; treatment₂: IBA of 100 g·kg⁻¹ + NAA of 300 g·kg⁻¹), after then the cuttings were cultured in culture media. On 15 Nov, 2000, 10 seedlings were chosen as the materials for each treatment, and cleaned by water. The biomass in root, stem and leaf of the cutting seedling for *Liriodendron chinense* x *tulipifera* was measured directly through the drying method (at 150 °C). Then three of the ten seedlings were chosen as a group sample after being measured the biomass. Individual dried seedling samples were bulked, weighed, ground, and finely sieved. The C content of three organs (root, stem, leaf) was determined by K₂Cr₂O₇ solution. And the samples were digested using H₂SO₄—HClO₄ method. The content of N was determined by Kjeldahl method, and P was analyzed by the colorimetric methods referencing GB7888-87 (Dong 1996). K and Ca were determined by Atomic Absorption Spectroscopy.

Results

Biomass of the cutting seedlings

The result (Table 1) showed that the biomass of different organs was significantly different in each cutting seedling after treated, which was 0.18-0.99 g for adventitious root, 0.83-4.38 g for stem, and 0.15-0.83 g for leaf, respectively. The biomass of seedlings treated with auxin was higher than that of the control seedlings.

The average biomass for the adventitious root, stem and leaf was shown in Fig. 1. Obviously, the organ's biomass was remarkably increased with auxin concentration (treatment₁: 50 g·kg⁻¹ IBA + 300 g·kg⁻¹ NAA; treatment₂:

Foundation item: This paper was supported by Jiangsu Province Science Foundation (BE96350).

Biography: ZHANG Xiao-ping, (1972-), female, Ph. Doctor in Nanjing Forestry University, Nanjing 210037, P. R. China.

Received date: 2003-09-03

Responsible editor: Zhu Hong

100 g·kg⁻¹ IBA + 300 g·kg⁻¹ NAA). The biomass of root cultured in the treatment₁ and treatment₂ was for 0.423 g and 0.483 g, respectively, which was 18.04% and 34.79%

higher than that of the control. In the stem, the increase percentage was 60.23% and 63.64%. In the leaf, the increase percentage was 44.24% and 33.80% (Fig. 1).

Table 1. Biomass distribution of cutting seedlings

Repeats	Root/g			Stem/g			Leaf/g			(g)
	Control	Treatment ₁	Treatment ₂	Control	Treatment ₁	Treatment ₂	Control	Treatment ₁	Treatment ₂	
1	0.47	0.27	0.18	1.09	2.61	1.00	0.35	0.45	0.16	
2	0.19	0.47	0.29	0.89	1.45	0.91	0.23	0.70	0.41	
3	0.28	0.26	0.73	1.26	1.96	1.91	0.35	0.17	0.75	
4	0.20	0.45	0.99	1.24	0.99	2.05	0.21	0.41	0.83	
5	0.51	0.87	0.51	1.09	1.40	1.07	0.36	0.80	0.32	
6	0.25	0.78	0.70	1.66	1.60	4.38	0.21	0.58	0.72	
7	0.40	0.26	0.40	0.98	1.26	1.14	0.22	0.20	0.24	
8	0.26	0.37	0.47	1.97	1.91	1.73	0.13	0.17	0.54	
9	0.40	0.18	0.33	0.61	1.20	0.83	0.29	0.39	0.20	
10	0.33	0.32	0.23	1.22	2.77	1.06	0.29	0.29	0.15	

Notes: treatment₁: IBA of 50 g·kg⁻¹ + NAA of 300 g·kg⁻¹; treatment₂: IBA of 100 g·kg⁻¹ + NAA of 300 g·kg⁻¹.

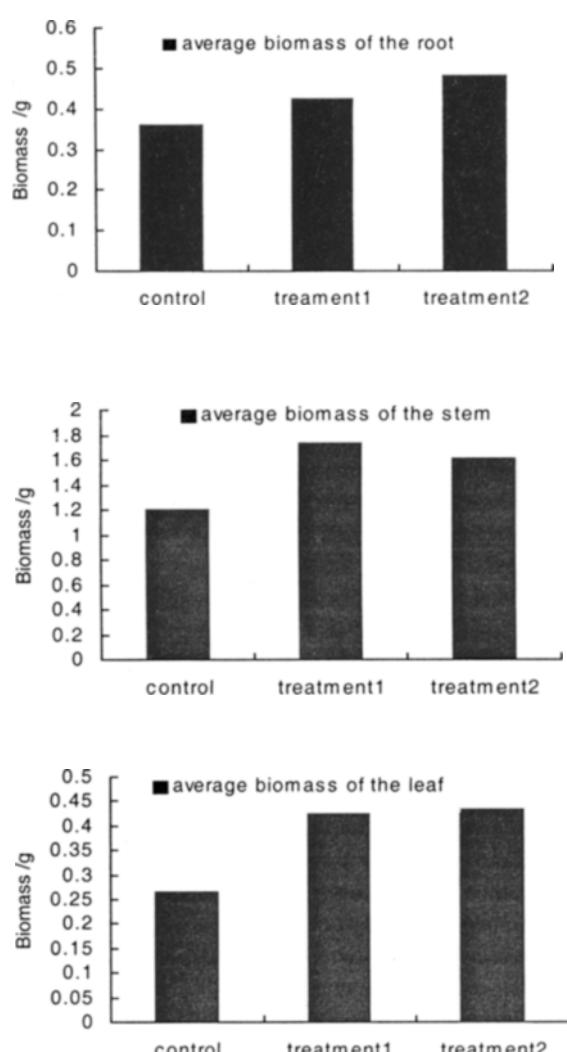


Fig. 1 Biomass of different organs from cuttings seedlings treated with auxin

The biomass of root, stem and leaf were significantly increased with concentration increasing of auxin (NAA+IBA), but the ratio of biomass in each organ to biomass in the whole seedling treated by auxin had no obvious difference. The distribution patterns of the biomass were 16%-20% for root, 64%-66% for stem, and 14%-17% for leaf. It is clear that the biomass of these organs (root, stem, leaf) was coordinately increased with auxin concentrations, but the ratio of biomass in each organ to biomass in the whole seedling treated by auxin was not obviously affected by the auxin concentrations.

Nutrient elements content of the cutting seedlings

In three organs, C content had no significant difference between the control and auxin treatments, and usually accounted for 50% of the biomass (Table 2). It is suggested that auxin treatment had no evident effect on C content in different organs. The results also showed that the N content of the seedling was very low in three organs, mostly less than 1%, which was a little lower in stem than that in root and leaf (both control and treatments). In the root, the ratio of C to N of treatment₂ was a little higher than that of the control and treatment₁, which was much higher in the stem.

Compared with the contents of N, K and Ca, the P content in different organs was much lower, especially in stem, mostly below 0.1%, which was lower than that in the root and leaf (mostly 0.1%-0.15%). The distribution pattern of nutrient element contents in different organs showed that the highest content occurred in the root, the medium in the leaf and the lowest in the stem.

The content of K in the same organ had no significant diversity with different treatments. K content in root of seedlings in the control group was higher than in that of the seedlings treated with auxin. The K content was the highest in root, and it was 2-4 times higher than that in stem and

1-2 times higher than that in leaf. The K content in leaf was 30%-50% higher than that in stem.

Table 2. Basic data of nutrient elements contents in seedlings

Organ	Repeat	C	N	C/N	P	K	Ca	(%)
Root	1	44.71	1.08	41.40	0.139	2.653	1.0874	
	Control	2	43.00	1.25	36.36	0.265	1.3578	0.9442
		3	45.97	0.59	77.92	0.096	1.2882	0.6885
	1	47.71	0.74	64.47	0.117	0.5833	0.9600	
	Treatment ₁	2	47.02	0.87	54.05	0.133	1.5275	0.8242
		3	46.04	0.62	74.26	0.111	0.6504	1.0940
Stem	1	44.47	0.90	49.41	0.168	1.0400	1.0209	
	Treatment ₂	2	45.52	0.57	79.86	0.099	0.9517	1.0042
		3	46.75	0.56	83.48	0.123	1.0797	0.8090
	1	54.28	0.90	60.31	0.094	0.3309	0.4876	
	Control	2	48.72	0.57	85.47	0.105	0.3723	0.5152
		3	49.79	0.58	85.84	0.049	0.2944	0.4124
Leaf	1	50.78	0.58	97.55	0.093	0.3460	0.6365	
	Treatment ₁	2	50.39	0.79	63.78	0.105	0.2555	0.9081
		3	48.87	0.77	63.47	0.049	0.3490	0.5728
	1	48.78	0.53	92.04	0.085	0.3230	0.3618	
	Treatment ₂	2	49.70	0.42	118.30	0.072	0.3368	0.4632
		3	47.99	0.44	109.07	0.064	0.2594	0.4900
	1	47.75	0.89	53.65	0.102	0.5499	1.1899	
	Control	2	49.09	0.92	53.36	0.133	0.3445	1.2548
		3	48.52	0.54	89.85	0.102	0.5671	1.3077
	1	48.73	1.31	37.20	0.140	0.5907	2.0636	
	Treatment ₁	2	49.50	1.32	37.50	0.103	0.2586	1.3446
		3	48.31	0.81	59.64	0.093	0.1684	1.6447
	1	46.55	1.10	42.32	0.125	0.5011	1.7146	
	Treatment ₂	2	44.79	0.78	57.42	0.126	0.5195	1.5113
		3	47.27	0.89	53.11	0.093	0.2845	1.6727

Notes: treatment₁: IBA of 50 g·kg⁻¹ + NAA of 300 g·kg⁻¹; treatment₂: IBA of 100 g·kg⁻¹ + NAA of 300 g·kg⁻¹.

Compared with the contents of N, P and K, the Ca content was the highest in the seedling. Ca content was 1.2%-2.1% in leaf, 0.7%-1.1% in root, and 0.4%-0.9% in stem. The auxin treatments did not increase the Ca contents in the root and leaf but raised the Ca content in stem.

Coefficient analysis suggested that there was no correlation between N, P, K and Ca. According to the variance analysis, in different organs, the ratio of C to N and the contents of P, K and Ca had significant difference for the same treatment, especially in treatment₂ (Table 3).

Table 3. Variance analysis of nutrient element contents among different auxin treatments

Items	F-value				
	df	C/N	P	K	Ca
Control	2	1.793	2.531	9.169 [*]	29.096 ^{**}
Treatment ₁	2	0.054	1.241	3.195	12.871 ^{**}
Treatment ₂	2	6.916	9.306	57.060 ^{**}	107.931 ^{**}

Notes: $F_{0.05}=5.1432$; $F_{0.01}=10.924$. * and ** respectively present significantly different in 95% and 99%.

Table 4. Variance analysis of nutrient element contents among different organs of seedling

Items	F-value				
	df	C/N	P	K	Ca
Root	2	1.877		0.194	2.197
Stem	2	9.231 ^{**}		3.683	0.257
Leaf	2	0.012		0.198	0.619

Notes: $F_{0.05}=4.2565$; $F_{0.01}=8.021$; * and ** respectively present significantly different in 95% and 99%.

The distribution tendency of the nutrient in the three organs was that the highest was in root, the medium in leaf, and the lowest in stem for P and K; but the order for Ca was leaf, root and stem. The low P content was examined in three organs. In the same organ, there was no distinct discrepancy between control and treatments based on variance analyzing, except the Ca content and the ratio C to N in the stem (Table 4). From this distribution trend of the nutrient elements in three organs, it can be seen that all contents of P, K and Ca were very low in the seedlings. This was disadvantageous to the adventitious root formation.

Perhaps this is one of the reasons why it is too difficult to induce the adventitious root.

Discussion

It had been recognized that the nutrition elements (especially their contents and distribution) were related to the adventitious root formation. Based on the observation of *Hibiscus rose-sinensis* L., Li (1997) found that it was advantageous to the root formation when added sucrose and glucose. Kraus and Kraybiu (1918) reported that high ratio of C to N was also beneficial to root primordium initiation and development in *Lycopersicon esculentum* Mill. And Zhao *et al.* (1997) suggested that both K and IAA were advantageous to the root primordium initiation, while K affected the root formation through increasing the IAA content. However, some studies showed a different result that the contents of different nutrition elements (K, Ca and B) did not evidently affect the adventitious root formation (Zhao *et al.* 1998).

In our study, the nutrient element content and its distribution in seedlings of hybrid species were analyzed. The biomass of the seedlings treated with auxin was increased, but there was no substantial difference in nutrient element content between control and treatments. The C content and ratio of C to N were higher than other nutrient elements content in the seedlings. The N content was rather low in different organs, which seemed to limit the root formation, and probably that was why the adventitious root was too hard to initiate. Fuente and Leopold studied the *Helianthus annuus* L. and it is suggested that, if the $[Ca^{2+}]$ was 10^{-6} - 10^{-5} M in the culture media, the transportation of IAA appeared to correlate positively with $[Ca^{2+}]$. In this paper, the content of each nutrient element was very low in the seedling, especially K and Ca, closely related to the root formation. The low N content would limit the internal IAA's function (Zhao *et al.* 1997). The low Ca content would confine the IAA's transportation, then the IAA in leaf could not immediately unload and effectively transport to the base of the cuttings. As a result, it was very disadvantageous to adventitious root formation.

Conclusions

External auxin increased the biomass content of the seedling, but had no effect on its distribution in different organs.

In all of the seedlings, the contents of N, P, K and Ca in the stem were much lower than that in root and leaf, but there existed no significant difference in contents of these elements in terms of same organ between treatment₁ (IBA of $50 \text{ g} \cdot \text{kg}^{-1}$ + NAA of $300 \text{ g} \cdot \text{kg}^{-1}$) and treatment₂ (IBA of

$100 \text{ g} \cdot \text{kg}^{-1}$ + NAA of $300 \text{ g} \cdot \text{kg}^{-1}$).

The N, P, K and Ca contents were very low in the root stem and leaf, which resulted in lack of nutrition in the seedlings. It is disadvantage to the adventitious root formation. Additional fertilizer should be applied in cutting practice.

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